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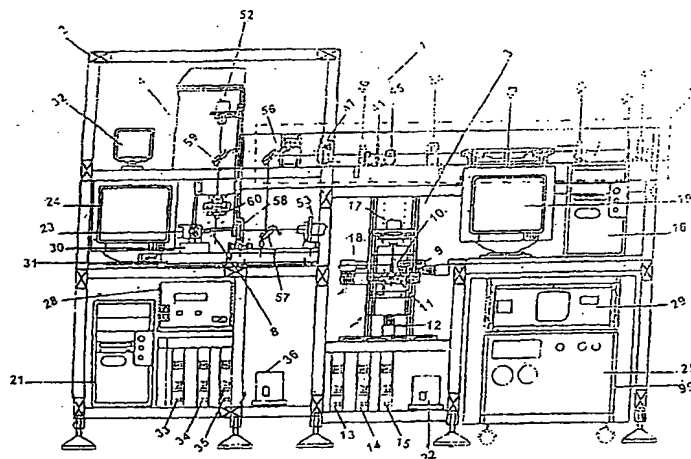
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(54) Title: A NOVEL LASER BRUTING MACHINE



(57) Abstract: A Novel Laser Bruting machine consists of mainly three sections (i) Diamond Holder (8) (ii) Set up device (3) & (iii) Processing device (4). Diamond holder (8) consists of rough diamond (5), stitching die (6) & magnetic die (7). Also the rough diamond stone to be centered and bruted is stitched on top of stitching die (6) by adhesive & heat. The stitching die (6) is then fixed on top of the magnetic die (7). Setup device (3) consist of CNC interface & video system. The diamond which is to be centered and hence diamond holder is put vertically on motorized rotatable platform (11). After completion of centering the diamond the diamond holder is carried to processing device & fixed horizontally on motorized rotatable platform (23) of processing device (4). Processing device consist of CNC Interface, Heat Exchanger (25), Video system, Beam delivery mechanism (26), Laser source (27), RF-Q Switch driver (28), Power supply (29) & stabilizer. Beam delivery mechanism of processing device consists of (i) Bruting process system and (ii) Girdle polishing system. With the standard software computer suggest an optimal cut to have accurate rounded shape of the diamond taking dimensions & shape into account.

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A NOVEL LASER BRUTING MACHINE.**Technical Field**

The present invention relates to A Novel Laser Bruting Machine.

The diamond has always exercised an irresistible seductive power and acquired an almost mythical fame because it is the most expensive of gems and the hardest of all minerals. Each diamond stone must therefore be studied in detail in order to determine the most advantageous manner to work it with the least loss of weight. In its unpolished form, a diamond is a rather vague crystal form, without any real luster. Only a succession of process such as marking, cleaving, sawing, girdling, etc. gives it its final facet form and brilliance. Girdling is the rounding of the base of sawn (or cleaved) piece so that it has more or less the form of a polished diamond. In conventional machine to achieve girdling of rough diamond stone, the sawn diamond is mounted on the chuck of a lathe and the desired rounded form is achieved by turning it against another diamond, as the cutting tool. The excess surface of the rough diamond cut with the conventional machine is imprecise. The conventional bruting machine works with lower speed and has the high weight loss. This is due to the cutting force spreads to other parts of the diamond. As each diamond is unique it has become imperative to develop new techniques in order to improve the productivity of the diamond industry.

Background Art

A novel laser bruting machine is invented to overcome above limitations experienced by conventional bruting machine. With a novel laser bruting machine, bruting becomes a non-contact very fast process compared to conventional bruting machine. As laser bruting being a non-contact process gives more speed, reduces weight loss significantly and keeps the shape of diamond uniform. In novel laser bruting machine the computer becomes an important element in cutting of diamond. With the standard software computer suggest an optimal cut to have accurate rounded shape of the diamond taking dimensions & shape into account. Also the rough diamond stone to be

centered and bruted is lit up by illuminating sources and these illuminating sources consist of plurality of LED's so the eye gets the impression that is always the same side of the stone that is lit and hence the illuminated rough diamond can be watched on CCTV through video system consist of CCD cameras. This is a useful technique, because novel bruting machine can check the process at all times without stopping the machine. Summing up all the advantages productivity increases considerably with a novel laser bruting machine.

Disclosure of the Invention:

The present invention will be described with greater specific and clarity with reference to following drawings:

- 10 **Fig. 1** represents front view of bruting machine.
- Fig. 2** represents diamond holder.
- Fig. 3** represents top view of rough diamond with possible maximum diameter
- Fig. 4** represents front view of setup device.
- 15 **Fig. 5** represents side view of setup device.
- Fig. 6** represents top view of setup device.
- Fig. 7** represents front view of bruting processing system.
- Fig. 8** represents front view of girdle polishing system.
- Fig. 9** represents block diagram of Beam delivery mechanism.
- 20 **Fig. 10** represents trolley containing power supply and heat exchanger.
- Fig. 11** represents block diagram of cooling system & chilling system of heat exchanger.
- Fig. 12** represents front view of chilling water tank.
- Fig. 13** represents front view of split tank.
- 25 **Fig. 14** represents diamond

Fig. 15 represents flow chart.

Fig. 16 a represents random/initial position of rough diamond stone.

Fig. 16 b represents position of center of rough diamond stone on X-axis.

Fig. 16 c represents position of rough diamond stone when it is centered.

5 **A Novel Laser Bruting Machine** consist of (i) diamond holder 8 (ii) Setup device 3, & (iii) processing device 4; diamond holder 8 consist of stitching die 6, magnetic die 7 and rough diamond 5; setup device 3 consist of CNC interface, video system; Processing device 4 consists of CNC interface, heat exchanger 25, video system, beam delivery mechanism 26, laser source 27, RF-Q Switch driver 28, power supply 29 & stabilizer.

10 Bruting machine 1 which is accommodated on aluminum frame 2 consists of mainly three sections.

(1) Diamond Holder 8

(2) Set up device 3

(3) Processing device 4

15 **(1) Diamond Holder 8:** A rough diamond 5 to be processed for Bruting or Girdle Polishing is stitched on top of the stitching die 6 by adhesive & heat. Due to magnetism of magnetic die 7, stitching die 6 is fixed on top of magnetic die 7. Combination of stitching die 6 and magnetic die 7 is referred to as Diamond holder 8.

20 An automated gemstone/rough diamond stone 5 centering and data management system is provided to setup device 3. The physical data of a rough diamond stone/gemstone 5 is determined relative to the measured spectral response of light energy incident to a gemstone 5. Gemstone 5 is illuminated by a plurality of light sources such that the spectral response of the gemstone 5 is captured as a pixel data set, gauged, quantified and recorded for future reference via CCD cameras. A setup device 3 provides a imaging station for the automated centering and quantifying physical
25 data of gemstone 5. The video system/ imaging station is linked to computer/analysis station for

communicating captured incident light data sets thereto. The analysis station/computer 16 employs a data processor and model database for assessing the physical data of the gemstone 5 by way of the communicated pixel data sets. The spectral response of a gemstone 5 to the incident light sources is quantified relative to model pixel data sets of the database and recorded for future reference therein. The operation of the setup device 3 is controlled by a control card and instruction set.

The data processor/control card of the analysis station/computer 16 provides an instruction set for facilitating communication with the setup device 3, analyzing communicated pixel sets. The instruction set includes analytical and statistical image models, which extract pertinent physical data of gemstone from the pixel data sets. Additionally, the analysis station includes mass storage memory devices for storing the reference value database; analysis instruction set, and report information, which may include text as well as visual data. The physical data of gemstone 5 are communicated from the setup device 3 to the computer 21 of processing device 4 by means of LAN.

The control data processor/control card of the setup device 3 & processing device 4 provides an instruction set for automating the steps necessary to precisely position and operate the imaging hardware. The imaging system/video system of set up device 3 & processing device 4 extract consistently and accurately, size, shape, and proportion information from the images of a gemstone 5 using the data processing instruction set.

(2) Setup device 3 consist of CNC Interface & Video System

(I) CNC INTERFACE: CNC Interface of setup device 3 comprising of Motorized X axis positioner 9, Motorized rotatable platform 11, Motorized up/down positioner 12, Drive cards 13,14,15, Control card , Computer 16 & Stepper Motors.

(II) Video System of setup device 3 consists of Upper CCD Camera 17 & Lower CCD camera

18.

For accurate girdling/rounding or to remove surrounding excess surface of rough diamond 5 it is essential that rough diamond 5 should have rotating/circular motion around its center point for which it is required that rough diamond 5 along with stitching die 6 should be placed on center of top of the magnetic die 7 and it is done by CNC Interface, Computer 16 with standard software and

5 Monitor 19.

Example:

Because of the Video system, rough diamond 5 appears on the monitor 19. As upper CCD camera 17 & Lower CCD camera 18 are being used, one has option for watching rough diamond 5 either in elevation or plan view. Supposing surface of the rough diamond 5 is being selected by 3-
10 point method considering top view/plan view of rough diamond 5. Then by mouse clicking three random end points of rough diamond 5 are selected and with standard software it gives physical data of rough diamond 5 and also puts stitching die 6 on center of top of the magnetic die 7 automatically using pusher rod 10 of motorized X axis positioner 9 & motorized rotatable platform 11. The physical data of rough diamond 5 & predicted finished diamond 20 can be accessed in
15 processing device 4 as computers 16 & 21 of setup device 3 and processing device 4 respectively are connected with LAN.

Functioning of CNC Interface of setup device 3 :

Example:

Referring to figure 16a, assume that center of rough diamond 5 is $P(x,y)$ and thus it is offset from
20 $O(0,0)$. It represents initial position of rough diamond 5 placed on motorized rotatable platform 11 vertically.

Referring to fig. 16b, computerized vision system will measure the angle to rotate and by rotary motion, center P of rough diamond 5 is brought on X axis through motorized rotatable platform 11. Stepper motor drives the motorized rotatable platform 11 and hence diamond holder 8 which is
25 placed on motorized rotatable platform 11 also rotates and takes the position on X-axis.

Referring to **fig16c**, to match the center P with O, Pusher rod 10 which is fixed with Motorized X axis positioner 9 pushes P towards O and hence stitching die 6 is placed on center of top of magnetic die 7. Motorized X axis positioner 9 is driven by stepper motor.

If elevation view or plan view of rough diamond 5 do not appear clearly on monitor 19 then
5 Motorized up/down positioner 12 comes into action to give clear image of rough diamond 5 on monitor 19 by moving vertically. Motorized Up/down positioner 12 is driven by stepper motor.

Drive cards 13,14 & 15 are connected to motorized X- axis positioner 9, motorized up/down positioner 12 & motorized rotatable platform 11 respectively. Drive cards 13,14,15 are also connected with computer 16. Drive cards 13,14,15 amplify the electronic signal coming from
10 computer 16 and provides amplified electronic signal to Motorized X axis positioner 9, Motorized up/down positioner 12, & Motorized rotatable platform 11. A control card which is placed in the computer 16 controls the movement of motorized X axis positioner 9, Motorized up/down positioner 12 & Motorized rotatable platform 11. Also limit switches are provided to each end of motorized X axis positioner 9, motorized rotatable platform 11 & motorized up/down positioner 12
15 to sense the home & end position. To switch on or off the drive cards 13,14,15, drive card power supply 22 is connected to drive cards 13,14,15.

(3) Processing device 4:

Diamond holder 8 is carried to processing device 4 following the process of centering the stitching die 6 on magnetic die 7. Diamond holder 8 is fixed horizontally on motorized rotatable
20 platform 23. As computer 16 of setup device 3 and computer 21 of processing device 4 are connected via LAN and hence physical data of rough diamond 5 taken from setup device 3 is accessed on monitor 24 through standard software installed in computer 21 of processing device 4.

Mechanism of processing device 4:

Processing device 4 consist of CNC Interface, Heat Exchanger 25, Video system, Beam
25 delivery mechanism 26, Laser source 27, RF-Q Switch driver 28 & Power supply 29.

(I) **CNC Interface** of processing device 4 consist of Motorized Y-axis positioner 30 ,Motorized rotatable platform s, Motorized X axis positioner 31, Computer 21, Monitor 24, CCTV 32, Drive cards 33,34,35, drive card power supply 36 & stepper motors to drive Motorized Y-axis positioner 30, Motorized rotatable platform 23 & Motorized X axis positioner 31.

5 (II) **Heat Exchanger 25** consist of Cooling system 37, Chilling system 38 ,Interlock system 39. Cooling system 37 associated with de-ionized water circulation from cooling system 37 to Laser head 43 & Q-switch 42 and vice versa. Chilling system 38 associated with water circulation from Heat exchanger 25 to chilling pump system 48 and vice versa. Chilling pump system 48 consist of chilling water tank 70 & split tank 71. Heat exchanger 25 is connected to Power supply 29 via
10 interlock cable. Interlock system 39 saves machine from getting damaged by switching off the power supply 29 automatically if (i) flow and/or (ii) level and/or (iii) temperature of de-ionized water unnecessarily decreases or increases. Interlock system 39 of heat exchanger 25 comprising of flow LED 49, Level LED 50 & Temperature LED 51.

(III) **Video system:** Video system of processing device 4 comprising of upper CCD Camera 52
15 and lower CCD camera 53.

(IV) **Beam delivery mechanism 26** of processing device 4 consists of (i) Bruting process system 54 and (ii) Girdle polishing system 55. Bruting process system 54 consists of (a) sliding beam bender 56 (b) lower beam bender 57 & (c) lower focusing device 58. Girdle Polishing system 55 consist of (a) upper beam bender 59 (b) upper focusing device 60. Sliding beam bender 56, lower
20 beam bender 57 and upper beam bender 59 are placed at 45° with respect to incoming laser beam.Lower focusing device 58 and upper focusing device 60 have illuminating source to illuminate rough diamond 5. Each illuminating source has plurality of LED's.

(V) **Laser Source 27** consist of back mirror 40, Apertures 41,41, Q-switch 42, Laser head 43, shutter s, polariser 45, front mirror 46 & beam expander 47.

25 Laser head 43 is the crucial part to generate the laser light. Front mirror 46 and back mirror 40

amplifies the laser light by providing feedback. Q-switch 42 is used to store the laser light energy to emit as a burst of high peak power. Safety shutter 44 blocks the laser beam in case of electrical failure. Safety shutter terminates laser by blocking the laser beam path and preventing emission of laser radiation out of the laser source. The safety shutter 44 is actuated by toggle switch. Apertures 41,41 restrict the light amplification along the off-axis of the resonator to provide sharp frequency band. Beam expander 47 expands the laser beam to minimize its divergence. To polarize laser beam polarizer 45 is used.

(VI) RF-Q Switch driver 28: To get the pulsed laser output with high peak power, the laser is operated in Q-Switch mode. The transducer in acoustic-optic Q-switch 42 requires RF power for operation of Q-switch 42 and such requirement is fulfilled by RF-Q Switch driver 28. The RF source is pulsed at frequencies from 0.1KHz to 50KHz corresponding to the desired pulse repetition rate of the laser. The quartz cell being switched with such a high frequency needs cooling. Therefore the Q-switch 42 also becomes cool. To operate Q-Switch 42 in pulsed mode, RF-Q Switch driver 28 is connected to Q-Switch 42 and computer 21. Computer 21 sends the frequency data to RF-Q switch driver 28 and accordingly laser in laser source is operated in Q-switch mode. As Q-switch 42 is being switched with such a high frequency, it is cooled by circulation of de-ionized water for repetitive operations and therefore interlock system is provided.

(VII) Power supply 29: It ignites and controls the intensity of the laser light emitted by the laser lamp (Kr/Xe arc lamp). The intensity of light produced by the lamp is used for pumping the Nd atoms in Nd:YAG rod. Once the discharge in the lamp is produced, then by changing the current flowing through the lamp, the intensity of light emitted by the lamp can be controlled. In many applications laser is not used continuously and therefore the power supply 29 is provided with a special feature of standby mode which keep alive the discharge in the lamp by producing the optimum current required for the lamp to maintain the discharge in lamp. This particular arrangement is very useful in increasing the operational life of the lamp and also that of power

supply. Because this will save the whole process of generating the trigger pulse for igniting the lamp.

Functioning of Processing Device 4:

A diamond holder 8 which consist of stitching die 6 and magnetic die 7 is carried from setup
5 device 3 and fixed horizontally to motorized rotatable platform 23. In bruting process laser beam coming from laser source 27 falls on sliding beam bender 56 from which it falls on lower beam bender 57 and hence laser beam coming from lower beam bender 57 which is then focused by lower focusing device 58 and finally the focused laser beam falls on gemstone/rough diamond stone 5. And therefore maximum diameter 61 of rough diamond stone/ gemstone 5 is achieved by
10 removing excess surface from it by rotary motion and displacement on particular axis.

Also maximum diameter 61 of rough diamond 5 is achieved with the girdle polishing process. In girdle polishing process laser beam coming from laser source 27 falls on upper beam bender 59 bypassing sliding beam bender 56. A laser beam coming from upper beam bender 59, which is then focused by upper focusing device 60 and hence focused laser beam falls on rough diamond stone 5.

15 Application of Bruting process 54 or Girdle polishing process 55 is to obtain maximum diameter 61 from rough diamond 5 by removing excess surrounding surface from rough diamond 5. After Bruting process 54 or Girdle polishing process 55 the shape of rough diamond 5 is converted into cylindrical shape in general. To remove excess surrounding surface of rough diamond 5 laser beam from laser source 27 is used.

20 Procedure for Switching on Heat exchanger 25 & Power supply 29:

Pump on/off knob 62 is accommodated in Heat exchanger 25, which is kept "on" initially and Pump LED 63 is operated by Pump on/off knob 62. Also digital temperature controlling unit 72 & Inter lock system 39 are provided to heat exchanger 25. Then in Power supply 29, T.P. 64 and Lamp 65 switches are switched "on" to trigger laser lamp of laser source 27. Also as power supply
25 29 is connected with heat exchanger 25 via interlock cable and therefore interlock LED 66 is

provided on power supply 29. Push button switch "Push for control" 67 is pressed to start current setting unit 68. The value displayed in current setting unit 68 can be varied by current variable knob 69. Current setting unit 68 is provided to have desired watt for cutting the surrounding excess surfaces of rough diamond 5. Heat exchanger 25 & Power supply 29 are accommodated in trolley 5 99.

Example:

The required heat in form of laser beam to cut the surrounding excess surface of the rough diamond 5 depends on the diamond quality. Supposing for a rough diamond 5 the required watt to cut the surrounding excess surface is 25 watt and to have such value current variable knob 69 of 10 power supply 29 is allowed to move until 25 watt is achieved in watt meter.

Application & functioning of Heat exchanger 25:

A large quantity of heat is generated inside the pumping cavity of laser source 27 when laser is produced. If the heat is not removed from the pumping cavity of laser source 27 then it will cause lamp and rod to get damaged and therefore a proper arrangement of heat distribution in terms of 15 heat exchanger 25 is provided to processing device 4. The heat from De-ionized water is subsequently removed by chilling system 38. The temperature of De-ionized water is regulated by means of solenoid, which turns outside water flow from chilling system 38 on and off as required.

Heat exchanger 25 consist of (i) Cooling system 37 (ii) Chilling system 38 and (iii) Interlock system 39. Cooling system 37 circulates de-ionized water from Heat exchanger 25 to Laser head 43 20 & Q-Switch 42 and vice versa. Also chilling system 38 circulates water from heat exchanger 25 to chilling pump system s and vice versa.

In heat exchanger 25 water circulation from chilling pump system 48 decreases the temperature of incoming de-ionized water at significant level and provides de-ionized water having less temperature to laser head 43 and Q-switch 42. Flow of water from chilling system 38 used for 25 decreasing temperature of incoming de-ionized water from cooling system 37 is getting heated and

hence temperature of such water increases. The temperature of such water is required to decrease by means of chilling pump system 48. Chilling pump system 48 consists of split tank 71 and chilling water tank 70.

Example:

5 Supposing display of digital temperature controlling unit 72 of Heat Exchanger 25 shows temperature of de-ionized water as 35°C. Now if it is required that temperature of de-ionized water should be 30°C then press SET switch of digital temperature controlling unit 72 for few seconds. When present temperature of de-ionized water (35°C) blinks then press up/down push button switches until required temperature 30°C displayed on the display of digital temperature controlling
10 unit 72. Press the SET push button switch of digital temperature controlling unit 72 when 30°C displayed on display of digital temperature controlling unit 72. After few moments as temperature of de-ionized water is set at 30°C the chilling pump system 48 of Heat exchanger 25 which decreases the temperature of incoming de-ionized water stops working. Though functioning of chilling pump system 48 remains continue.

15 **Functioning of Chilling pump system 48 of heat exchanger 25:**

Digital temperature control unit 73 is provided to chilling water tank 70. When in display of digital temperature control unit 73 if value of present water temperature is significantly higher than the value of set water temperature then split tank 71 starts working and if value of present water temperature remains around the value of set water temperature then split tank 71 stops working. In
20 this way the Chilling pump system 48 saves the power substantially.

Hence with the Heat exchanger 25, temperature can be maintained and the same saves the machine from getting overheated.

IN port 74 of Heat exchanger 25 is connected to one end of Teflon connector 75 via hose pipe 82 while other two ends of Teflon connector 75 are connected to OUT port 76 of laser head 43 and
25 OUT port 77 of Q-switch 42 via hose pipes 83,84 respectively. OUT port 78 of Heat exchanger 25

is connected to one end of Teflon connector 79 via hose pipe 85 while other two ends of Teflon connector 79 are connected to IN port 80 of laser head 43 and IN port 81 of Q-switch 42 via hose pipes 86,87 respectively. OUT port 78 of Heat exchanger 25 provides de-ionized water to Laser head 43 and Q-Switch 42 through IN port 80 and IN port 81 respectively while due to laser heat
5 warm de-ionized water come out from OUT port 76 and OUT port 77 of Laser head 43 and Q-switch 42 respectively and enters into Heat exchanger 25 through IN Port 74.

Chilling OUT port 88 of Heat exchanger 25 is connected to IN port 89 of chilling water tank 70 via hose pipe 95 and OUT port 90 of Chilling water tank 70 is connected to IN port 91 of Split tank 71 via hosepipe 96. OUT port 92 of split tank 71 is connected to dual port 93 of chilling water
10 tank 70 via hose pipe 97 and other end of dual port 93 of chilling water tank 70 is connected to Chilling IN port 94 of Heat exchanger 25 via hose pipe 98.

Water used to decrease the temperature of de-ionized water becomes warm and comes out from chilling OUT port 88 of Heat exchanger 25 and travels towards IN port 89 of Chilling water tank 70. Then this warm water travels into split tank 71 and split tank 71 decreases temperature of warm
15 water and provides such water to chilling water tank 70 and from chilling water tank s water travels into Heat exchanger b through IN port 94.

Functioning of beam delivery mechanism 26 of Processing device 4:

If bruting process is selected on monitor 24 through software installed in computer 21 ,laser beam falls on sliding beam bender 56. Then laser beam falls on lower beam bender 57 from which
20 it travels towards lower focusing device 58 and hence focused laser beam falls on side of a rough stone 5 accommodated on diamond holder 8.

If Circle polishing process is selected on monitor 24 through software installed in computer 21 then laser beam falls on upper beam bender 59 bypassing sliding beam bender 56. Now laser beam passes through upper focusing device 60 and hence focused laser beam falls on rough stone 5
25 accommodated on diamond holder 8.

Also upper focusing device 60 and lower focusing device 58 have illuminating component to illuminate rough diamond 5 by means of plurality of surrounding LED's for watching bruting process or girdle polishing process on CCTV 32.

Functioning of CNC interface of processing device 4:

5 Motorized Rotatable Platform 23:

Surrounding excess surface of rough diamond 5 is removed by laser beam due to rotation of motorized rotatable Platform 23 on which diamond holder 8 is mounted horizontally. To drive the motorized rotatable platform 23, stepper motor is used.

Motorized Y-axis positioner 30 and Motorized X-axis positioner 31:

10 During Bruting process, laser beam dipping into rough diamond 5 gradually until the maximum diameter 61 or cylindrical shape of the diamond achieved for which displacement of rough diamond 5 through motorized rotatable platform 23 on Y- axis and/or X-axis is required which is accomplished by motorized Y-axis positioner 30 and/or motorized X-axis positioner 31. Motorized Y-axis positioner 30 is mounted on Motorized X-axis positioner 31 in such a way that Motorized
15 Y-axis positioner 30 can travel on Motorized X-axis positioner 31. Displacement of motorized X-axis positioner 31 and/or motorized Y-axis positioner 30 is done automatically or by manual data feed through software installed in computer 21.

Movement of Motorized Y-axis positioner 30, Motorized X-axis positioner 31 and rotation of motorized rotatable platform 23 are controlled by control card installed in computer 21.

20 As Y-drive card 33 is connected to computer 21 & motorized Y-axis positioner 30, it amplifies the electronic signal coming from computer 21 and send amplified signal to motorized Y-axis positioner 30. Similarly X-drive card 34 and R-drive card 35 send amplified electronic signals to Motorized X-axis positioner 31 and Motorized Rotatable platform 23 respectively. Y-drive card 33, X-drive card 34 and R-drive card b can be switched on/off through drive card power supply 36
25 connected to them. Motorized Y- axis positioner 30 and Motorized X-axis positioner 31 are driven

by stepper motors. Also limit switches are provided to each end of Motorized Y axis positioner 30 , Motorized X axis positioner 31 & motorized rotatable platform 23 to sense the home & end position.

5 A rough diamond 5 to be processed for bruting or girdle polishing can be watched on CCTV 32 through video system of processing device 4 consist of upper CCD camera 52 and lower CCD camera 53.

As laser bruting being a non-contact process gives more speed, reduces weight loss significantly and keeps the shape of diamond uniform. In novel laser bruting machine the computer becomes an important element in cutting of diamond. With the standard software computer suggest
10 an optimal cut to have accurate rounded shape of the diamond taking dimensions & shape into account. Also the rough diamond stone to be centered and bruted is lit up by illuminating sources and these illuminating sources consist of plurality of LED's so the eye gets the impression that is always the same side of the stone that is lit and hence the illuminated rough diamond can be watched on CCTV through video system consist of CCD cameras. This is a useful technique,
15 because novel bruting machine can check the process at all times without stopping the machine and the same can be operated by a single person. Summing up all the advantages productivity increases significantly by using novel laser bruting machine.

20

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CLAIMS

1. **A Novel Laser Bruting Machine** consist of (i) diamond holder 8 (ii) Setup device 3, & (iii) processing device 4; diamond holder 8 consist of stitching die 6, magnetic die 7 and rough diamond 5; setup device 3 consist of CNC interface, video system; Processing device 4
5 consists of CNC interface, heat exchanger 25, video system, beam delivery mechanism 26, laser source 27, RF-Q Switch driver 28 ,power supply 29 & stabilizer.
2. **A Novel Laser Bruting Machine** as claimed in claim 1 wherein rough diamond 5 is stitched on the top of stitching die 6 by adhesive & heat; stitching die 6 along with rough diamond b is fixed on top of magnetic die 7.
- 10 3. **A Novel Laser Bruting Machine** as claimed in claim 1 wherein CNC interface of setup device 3 consists of motorized X axis positioner 9, motorized rotatable platform 11, motorized up/down positioner 12, drive cards 13,14,15, control card, computer 16, monitor 19, three stepper motors, drive card power supply 22.
4. **A Novel Laser Bruting Machine** as claimed in claims 1,3 wherein motorized X axis
15 positioner 9, motorized rotatable platform 11, motorized up/down positioner b are driven by stepper motors.
5. **A Novel Laser Bruting Machine** as claimed in claims 1,3 wherein one end of drive cards 13, 14 & 15 are connected to motorized X-axis positioner 9, motorized up/down positioner 12 & motorized rotatable platform 11 respectively & other end of drive cards 13,14,15 connected to
20 drive card of computer16 through 37pin connector ;drive cards 13,14,15 are connected to drive card power supply 22.
6. **A Novel Laser Bruting Machine** as claimed in claims 3,4,5 wherein motion of motorized X axis positioner 9, motorized rotatable platform 11, motorized up/down positioner 12 is controlled by drive card placed in computer 16; limit switches are provided to each end of
25 motorized X axis positioner 9, motorized rotatable platform 11, motorized up/down positioner

12 to sense the home & end position.

7. **A Novel Laser Bruting Machine** as claimed in claim 1 wherein video system of setup device 3 is connected to computer 16 & it consists of Upper CCD camera 17 & Lower CCD Camera 18.

5 8. **A Novel Laser Bruting Machine** as claimed in claim 1 wherein CNC interface of processing device 4 consists of motorized Y-axis positioner 30, motorized rotatable platform 23, motorized X axis positioner 31, computer 21, monitor 24, CCTV 32, Y drive card 33, X drive card 34, R drive card 35, drive card power supply 36, three stepper motors, control card.

10 9. **A Novel Laser Bruting Machine** as claimed in claim 8 wherein motorized Y-axis positioner 30, motorized rotatable platform 23, motorized X axis positioner 31 are driven by stepper motors.

10. **A Novel Laser Bruting Machine** as claimed in claims 8,9 wherein one end of Y drive card 33, R drive card 35 & X drive card 34 are connected to motorized Y-axis positioner 30, motorized rotatable platform 23, & motorized X axis positioner 31 respectively and other end of Y drive card 33, R drive card 35, X drive card 34 are connected to control card of computer 21 through 37 pin connector; Y-drive card 33, X drive card 34, R drive card 35 are connected to drive card power supply 36.

11. **A Novel Laser Bruting Machine** as claimed in claim 8 wherein motion of motorized Y-axis positioner 30, motorized rotatable platform 23, motorized X axis positioner 31 are controlled by control card of computer 21.

12. **A Novel Laser Bruting Machine** as claimed in claim 8 wherein displacement of rough diamond 5 of diamond holder 8 via motorized rotatable platform 23 on Y-axis and X-axis is accomplished by motorized Y-axis positioner 30 and motorized X-axis positioner 31 respectively; motorized Y-axis positioner 30 and motorized X-axis positioner 31 are mounted

in such a way that motorized Y-axis positioner 30 can travel on motorized X-axis positioner 31.

13. **A Novel Laser Bruting Machine** as claimed in claim 8 wherein limit switches are provided to each end of Motorized Y axis positioner 30 , Motorized X axis positioner 31 & motorized rotatable platform 23 to sense the home & end position.

14. **A Novel Laser Bruting Machine** as claimed in claim 1 wherein video system of processing device 4 is connected to computer 21 & it consist of upper CCD camera 52 and lower CCD camera 53.

15. **A Novel Laser Bruting Machine** as claimed in claim 1 wherein heat exchanger 25 of processing device 4 is connected to power supply 29 and RF Q-switch driver 28; digital temperature controller 72, LED's 49,50,51 of interlock controller for flow, level & temperature indication of de-ionized water, pump on/off knob 62, pump LED 63 are accommodated in heat exchanger 25.

16. **A Novel Laser Bruting Machine** as claimed in claims 1,15 wherein heat exchanger 25 consist of cooling system 37, chilling system 38; cooling system 37 circulates de-ionized water while chilling system 38 circulates water; In cooling system 37 IN port 74 of heat exchanger 25 is connected to one end of Teflon connector 75 via hose pipe 82 while other two ends of Teflon connector 75 are connected to OUT port 76 of laser head 43 and OUT port 77 of Q-switch 42 via hose pipes 83,84 respectively; OUT port 78 of heat exchanger 25 is connected to one end of Teflon connector 79 via hose pipe 85 while other two ends of Teflon connector 79 are connected to IN port 80 of laser head 43 and IN port 81 of Q-switch 42 via hose pipes 86,87 respectively; chilling system 38 consist of chilling pump system 48; chilling pump system 48 consist of split tank 71, chilling water tank 70; digital temperature controller 73 is connected to chilling water tank 70; chilling OUT port 88 & chilling IN port 94 of heat exchanger 25 are connected to chilling pump system 48; chilling OUT port 88 of

heat exchanger 25 is connected to IN port 89 of chilling water tank 70 via hose pipe 95 and OUT port 90 of chilling water tank 70 is connected to IN port 91 of split tank 71 via hosepipe 96. OUT port 92 of split tank 71 is connected to dual port 93 of chilling water tank 70 via hose pipe 97 and other end of dual port 93 of chilling water tank 70 is connected to chilling IN port 94 of heat exchanger 25 via hose pipe 98.

17. **A Novel Laser Bruting Machine** as claimed in claim 1 wherein Beam delivery mechanism 26 of processing device 4 consists of Bruting process system 54, Girdle polishing system 55.

18. **A Novel Laser Bruting Machine** as claimed in claim 17 wherein Bruting process system 54 consists of sliding beam bender 56, lower beam bender 57, lower focusing device 58.

19. **A Novel Laser Bruting Machine** as claimed in claims 17,18 wherein Girdle Polishing system 55 consist of upper beam bender 59, upper focusing device 60; Sliding beam bender 56, lower beam bender 57 and upper beam bender 59 are placed at 45° with respect to incoming laser beam; each of the beam benders 56,57,59 bends the laser beam at 90°; Lower focusing device 58 and upper focusing device 60 focuses the incoming laser beam; Lower focusing device 58 and upper focusing device 60 have illuminating source to illuminate rough diamond 5; Each illuminating source of lower focusing device 58 & upper focusing device 60 have plurality of LED's.

20. **A Novel Laser Bruting Machine** as claimed in claim 1 wherein laser source 27 consist of back mirror 40, apertures 41, 41, Q-switch 42, laser head 43, shutter 44, polariser 45, front mirror 46 & beam expander 47.

21. **A Novel Laser Bruting Machine** as claimed in claim 1 wherein RF Q Switch driver 28 is connected to computer 21, Q- Switch 42 & heat exchanger 25.

22. **A Novel Laser Bruting Machine** as claimed in claim 1 wherein stabilizer is connected to power supply 29; T.P. switch 64, Laser lamp on/off toggle switch 65, current setting unit 68, push button on/off switch 67 of current setting unit 68, current variable knob 69 are provided

to power supply 29.

23. **A Novel Laser Bruting Machine** as claimed in claims 3,8,17 wherein computers **16&21** are connected by LAN and the computer program for bruting process system **54** & girdle polishing system **55** is substantially described in flow chart in accompanying figure.

5 24. **A Novel Laser Bruting Machine** substantially herein described with reference to the foregoing description and the accompanying drawings.

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AMENDED CLAIMS

[received by the International Bureau on 11 March 2004 (11.03.04);
original claim 24 cancelled;
remaining claims unchanged (1 page)]

to power supply 29.

23. **A Novel Laser Bruting Machine** as claimed in claims 3,8,17 wherein computers **16&21** are connected by LAN and the computer program for bruting process system **54** & girdle polishing system **55** is substantially described in flow chart in accompanying figure.

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1/16

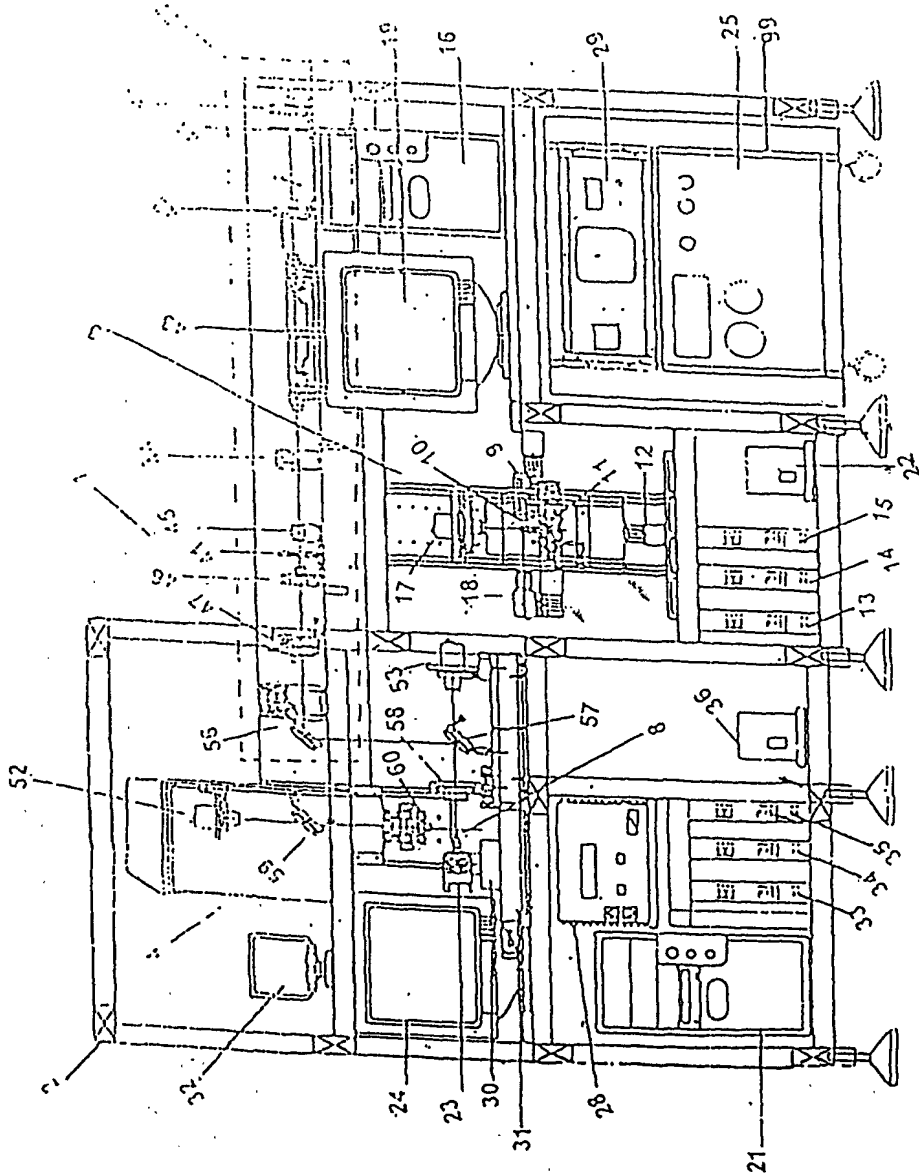


Fig. 1

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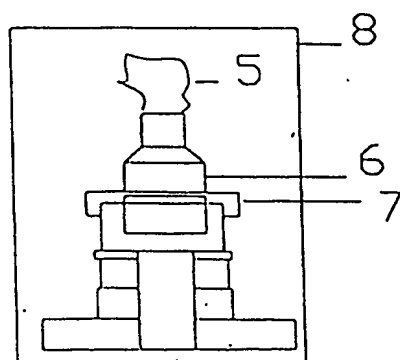


Fig. 2

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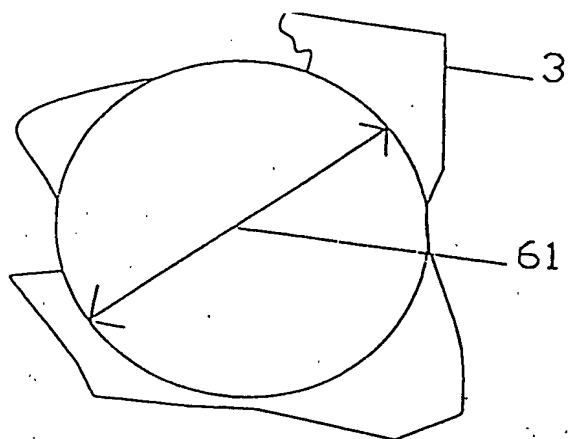


Fig. 3

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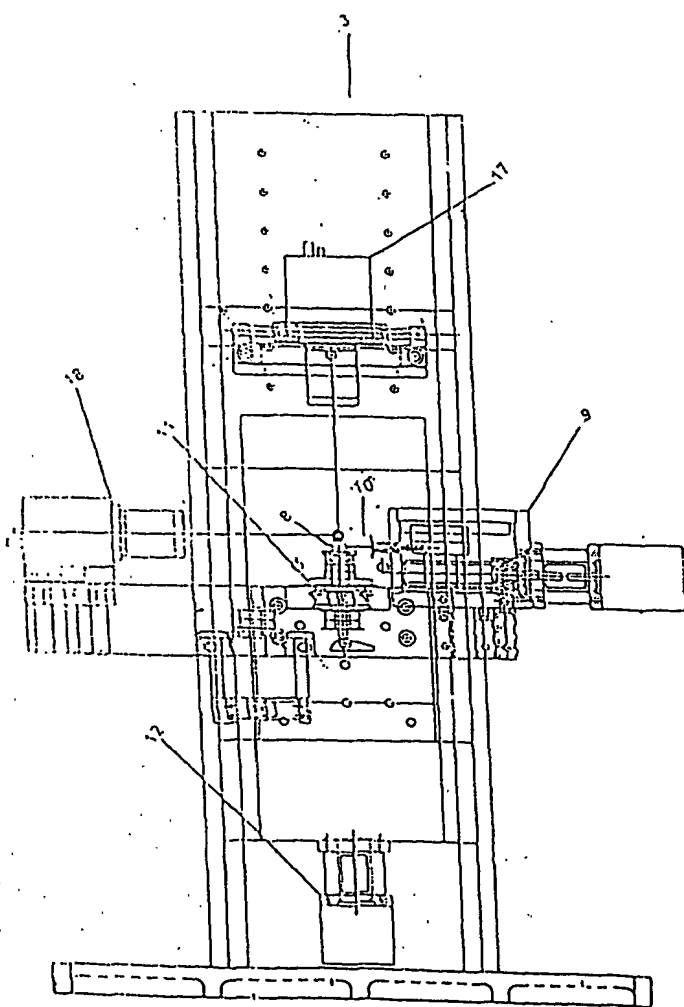


Fig. 4

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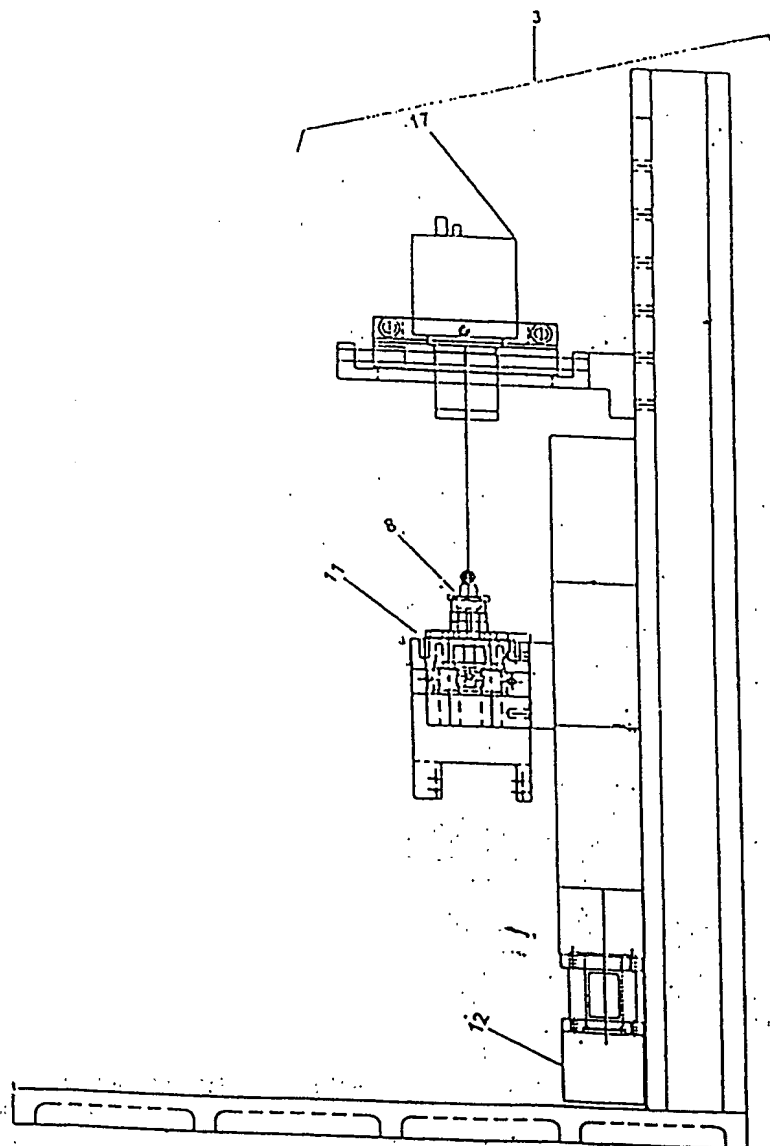


Fig.5

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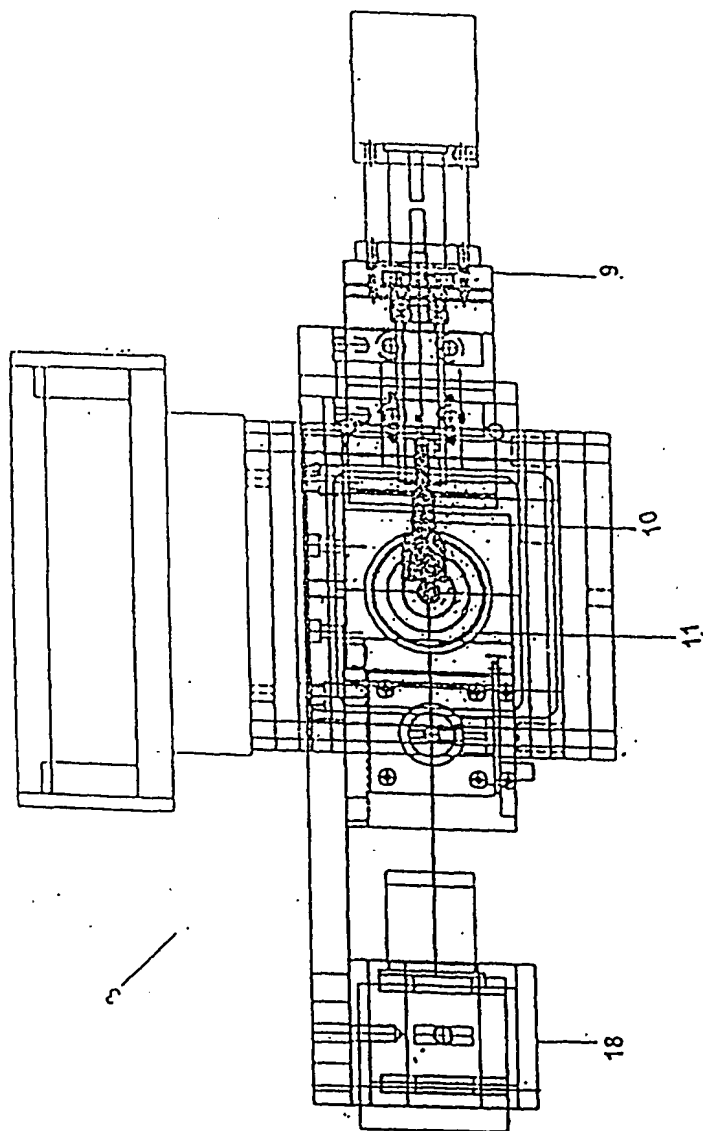


Fig. 6

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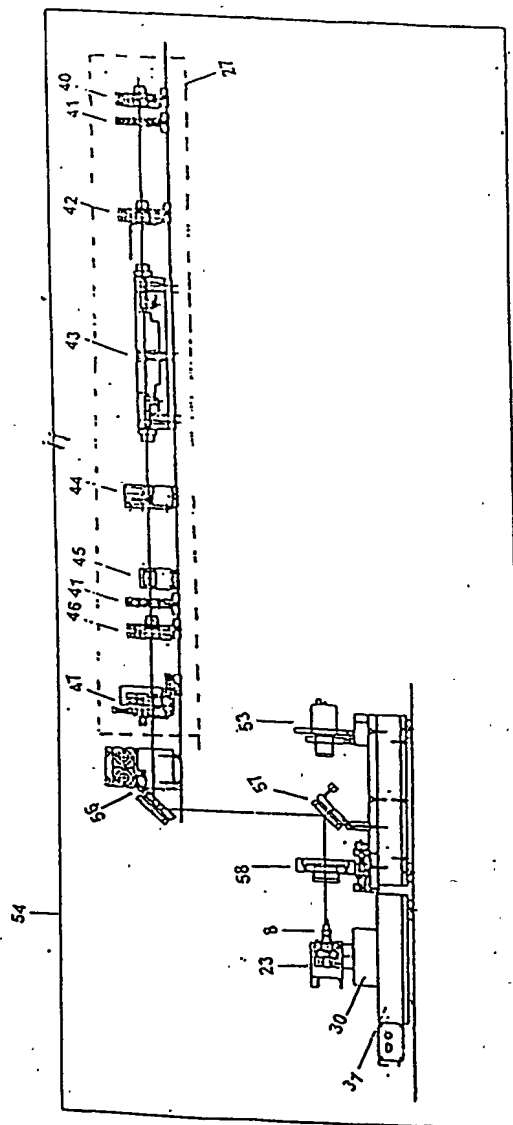


Fig. 7

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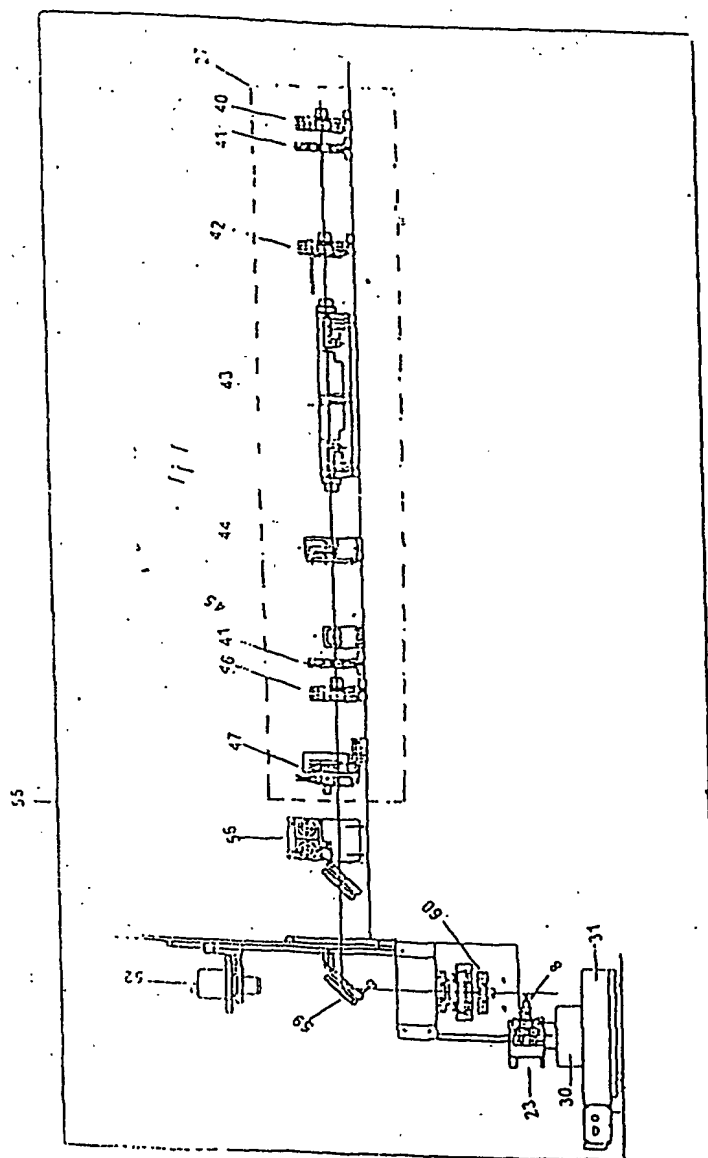


Fig. 8

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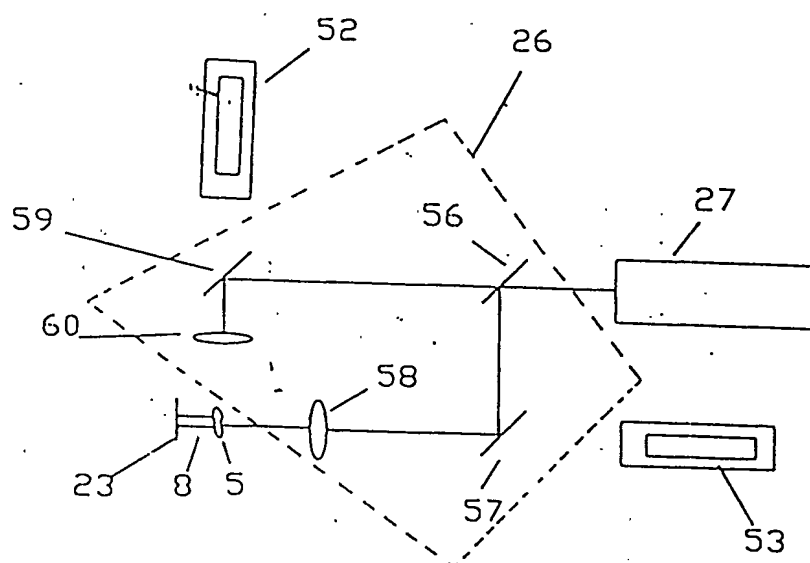


Fig.9

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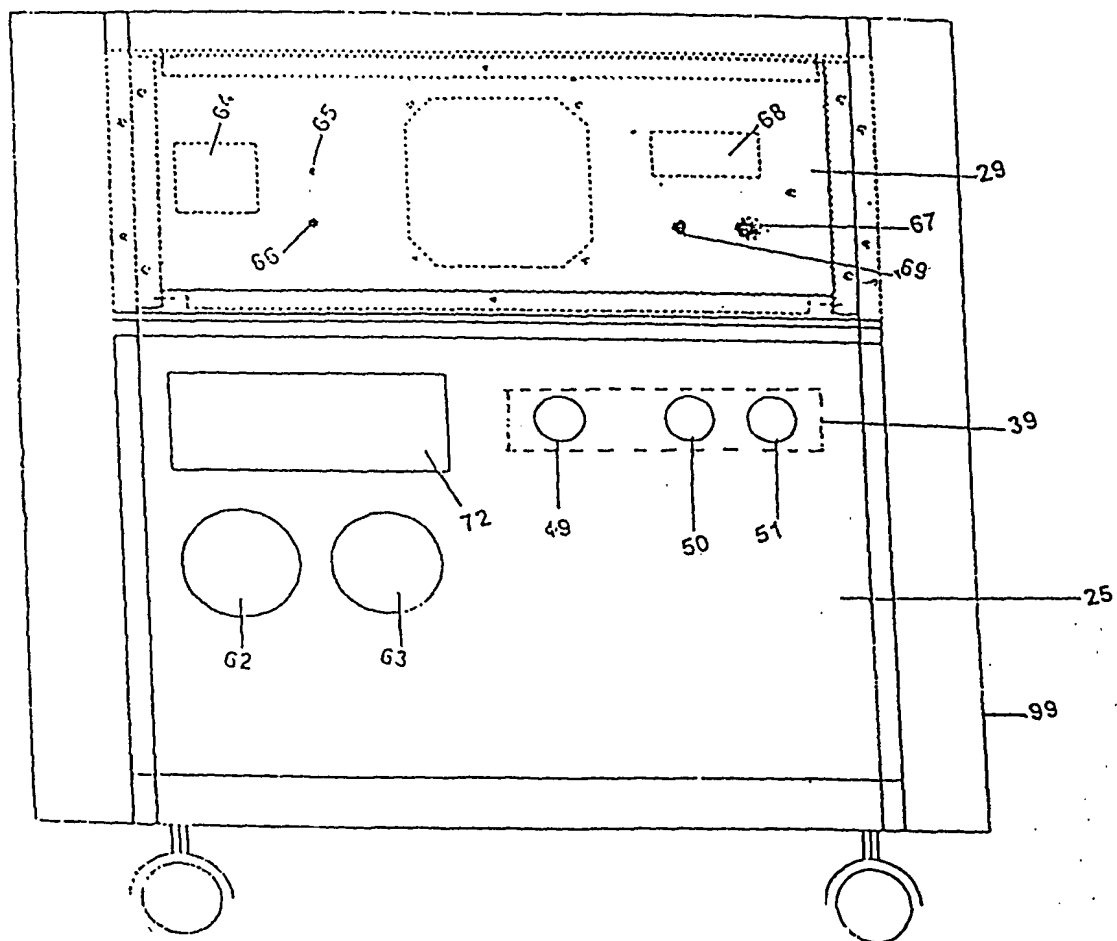


Fig. 10

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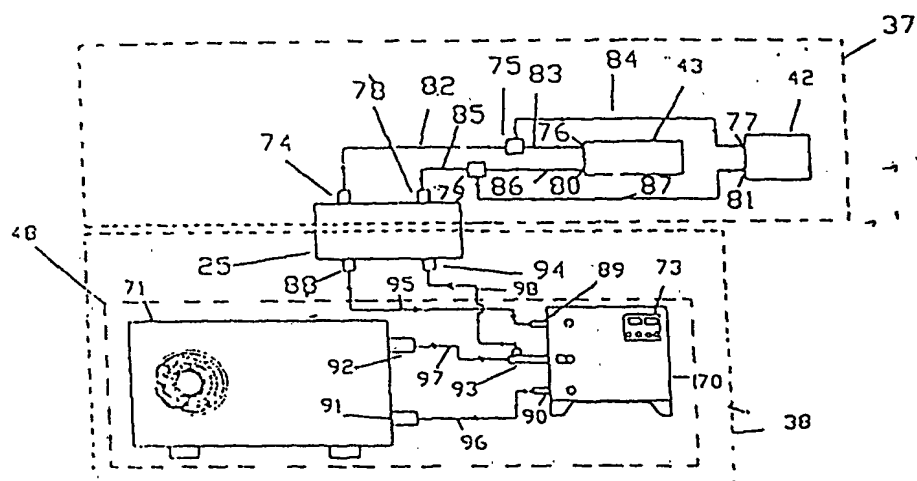


Fig. 11

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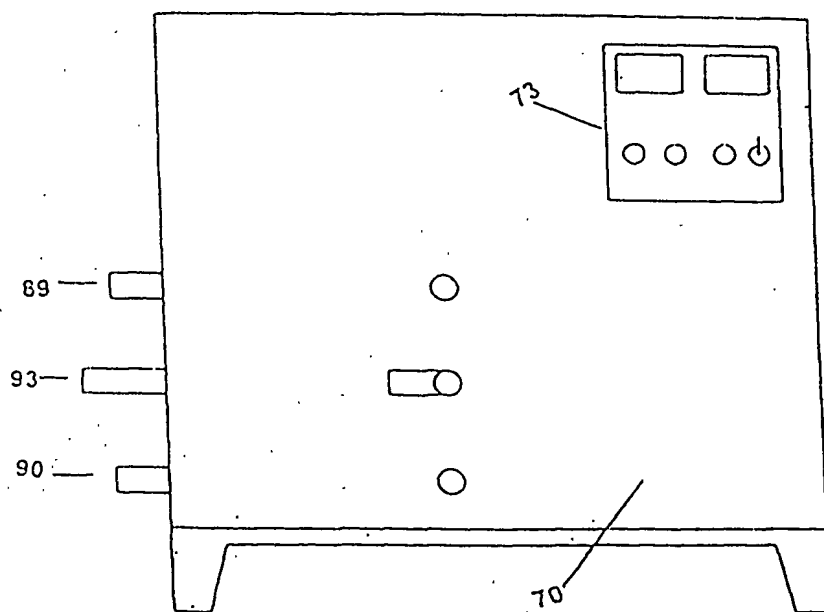


Fig. 12

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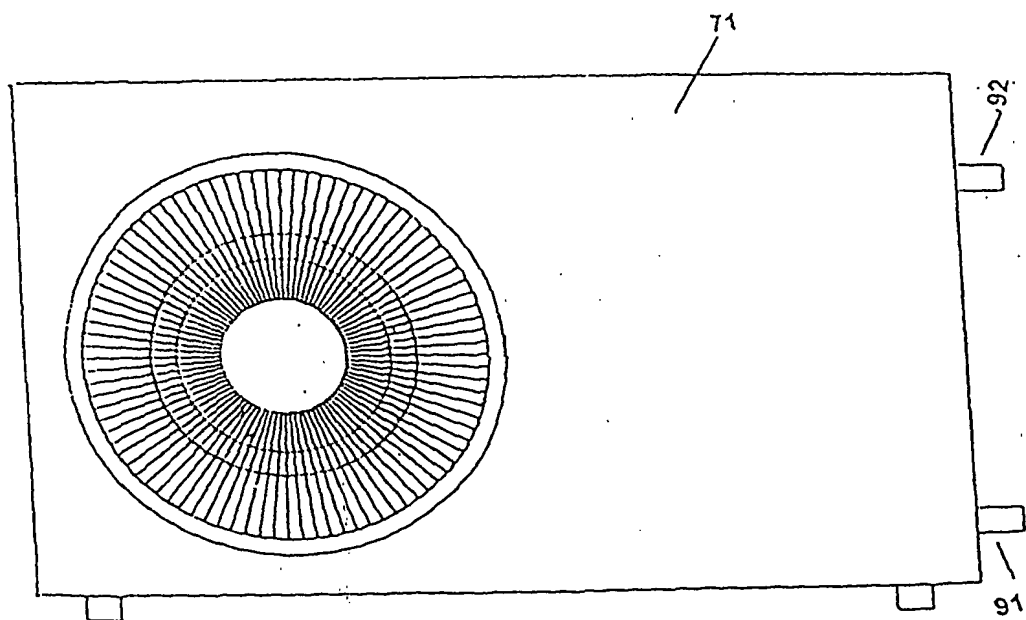


Fig. 13

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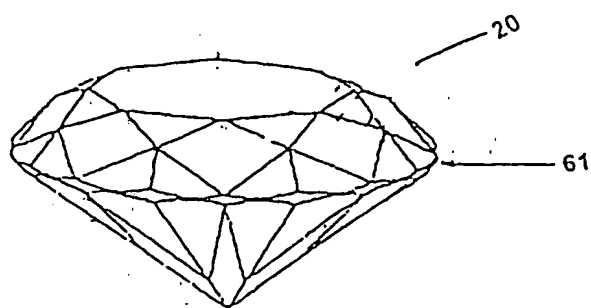


Fig.14

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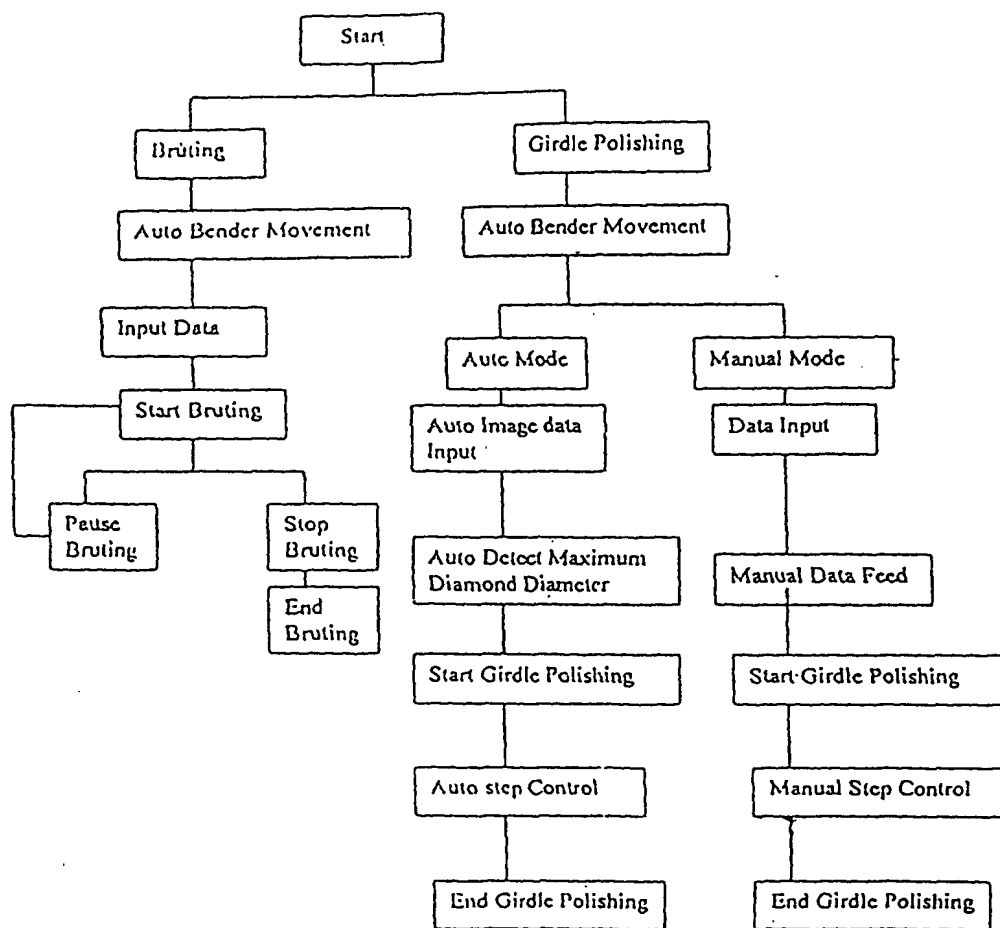


Fig. 15

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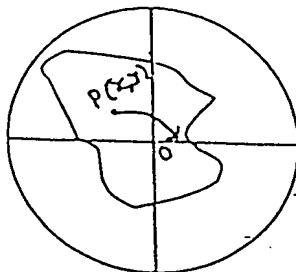


Fig. 16a

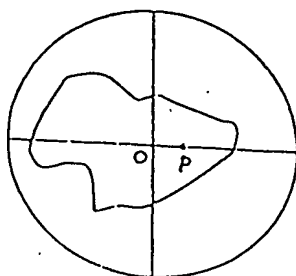


Fig. 16b

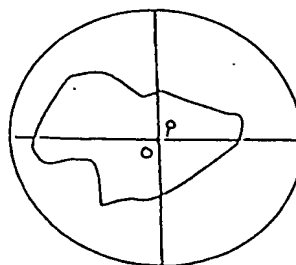


Fig. 16c
Fig. 16

INTERNATIONAL SEARCH REPORT

International Publication No.
PCT/IN 03/00245-0

CLASSIFICATION OF SUBJECT MATTER

IPC⁷: B24B 9/16; B23K 26/00; B28D 5/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC⁷: B24B; B23K; B28D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPODOC; WPI; PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5932119 A (Kaplan et al.) 3 August 1999 (03.08.99) <i>figures 2,6,9,10; abstract.</i>	1,3-15,20-21
A	US 5190024 A (Senanayake) 2 March 1993 (02.03.93) <i>figure 10; abstract.</i>	1,2

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:

„A“ document defining the general state of the art which is not considered to be of particular relevance

„E“ earlier application or patent but published on or after the international filing date

„L“ document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

„O“ document referring to an oral disclosure, use, exhibition or other means

„P“ document published prior to the international filing date but later than the priority date claimed

„T“ later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

„X“ document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

„Y“ document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

„&“ document member of the same patent family

Date of the actual completion of the international search

15 January 2004 (15.01.2004)

Date of mailing of the international search report

13 February 2004 (13.02.2004)

Name and mailing address of the ISA/AT

Austrian Patent Office

Dresdner Straße 87, A-1200 Vienna

Facsimile No. 1/53424/535

Authorized officer

SCHULTZ M.

Telephone No. 1/53424/344

INTERNATIONAL SEARCH REPORTInternational application No.
PCT/IN 03/00245-0**Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)**

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☒ Claims Nos.: 24
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
In this claim no specific feature of the invention is given.

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/IN 03/00245-0

Patent document cited in search report			Publication date	Patent family member(s)			Publication date
US	A	5190024	1993-03-02	IN	A	174710	1995-02-18
				ZA	A	8908713	1990-09-26
				CN	A	1042685	1990-06-06
				WO	A	9005624	1990-05-31
				EP	A	0561770	1993-09-29
US	A	5932119		IL	A	140513	2003-09-17
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				RU	C	2205733	2003-06-10
				CN	A	1425912	2003-06-25
				US	A	2003019852	2003-01-30
				US	B	6476351	2002-11-05